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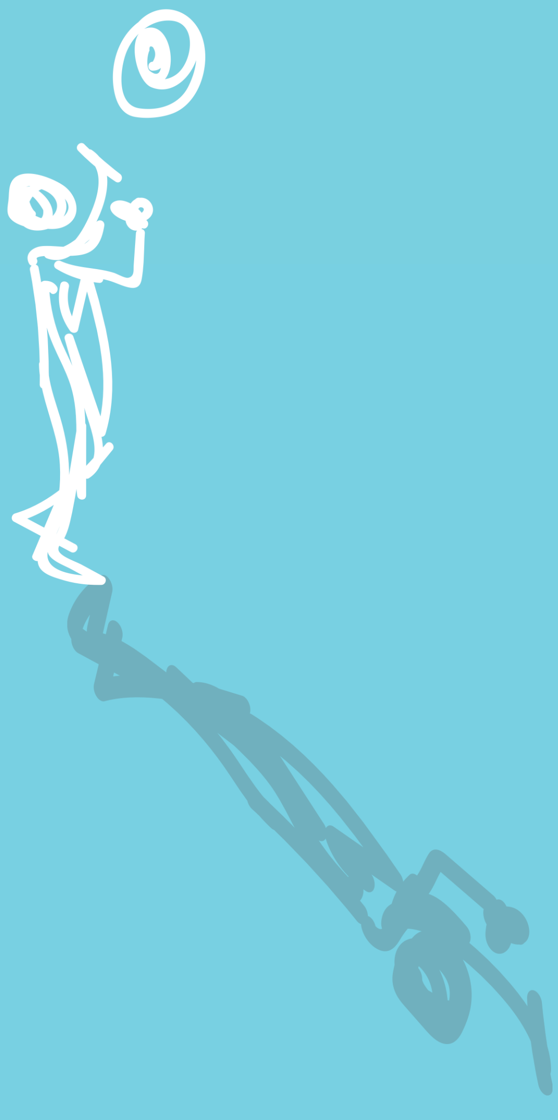
[SECTION 3]

VALIDITY OF THE 4-SKILLS SCAN



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CONCURRENT VALIDITY AND DISCRIMINATIVE ABILITY OF DUTCH PERFORMANCE-BASED MOTOR TESTS IN 5-YEAR-OLD CHILDREN

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Abstract

Aim. To assess the concurrent validity and discriminative ability of total, gross and fine motor scores of Dutch performance-based motor tests, the Baecke-Fassaert Motor Test (BFMT) and the 8- and 4-Skills Scan when compared with the Movement Assessment Battery (MABC) for children at age 5 as reference standard.

Method. 116 Dutch children (40.3% boys) were included. Spearman's rho correlations and area under the curves (AUC) were assessed.

Results. The total motor scores for MABC and BFMT strongly correlated (r= -0.58), while moderate correlations were observed for the fine motor scores (r= -0.40). For the gross motor scores, correlations between the three tests ranged from -0.51 to -0.65. Gross and fine motor scores had weaker correlations, ranging from 0.30 to 0.45, both within tests and between tests. With the MABC as reference (15th percentile), the AUC of the BFMT, 8- and 4-Skills Scan was 0.853 (95% CI: 0.757-0.949), 0.905 (95% CI: 0.837-0.972) and 0.844 (95% CI: 0.730-0.957), respectively. At optimal cut-offs, as determined by the Youden Index, the sensitivity and specificity of the BFMT, the 8- and 4 Skills Scan were 78.6 and 78.4%, 92.2 and 73.2%, 78.6 and 76.3%, respectively.

Conclusion. All tests had a reasonably high discriminative ability, but adaptations are desired to meet the requirements for screening. The relatively weak correlation between gross motor and fine motor scores implies that tests should be normalized and validated separately for determining the gross and fine motor ability.

Introduction

A growing number of children have a motor delay as an isolated or more general developmental problem.[1] This may be partly due to increasing frequencies of preterm births resulting in a higher prevalence of congenital developmental problems, especially Developmental Coordination Disorder (DCD),[2] with a prevalence in childhood of 5 to 15%.[3,4] Another reason may be the rising frequency of under-stimulation due to the decreasing levels of physical activity in children.[5] Besides, the increased awareness of the relevance of motor development among both care providers and parents may have led to an increase in the identification of these problems.

Children with motor developmental problems often feel less socially accepted, have a lower self-efficacy, and higher levels of anxiety.[6–8] Consequently, these children participate less in physical activities, increasing the risk of becoming overweight with adverse consequences of their physical and psychosocial health. The resulting cumulative effects of motor developmental problems and under-stimulation may lead to an even relatively bigger deviation from normal development at later ages.[9]

Early assessment could help to minimize the adverse consequences of motor problems such as DCD. The earliest age at which DCD is usually assessed is 5 years.[4] Assessment before age 5 is not recommended, unless there is a severe motor impairment.[4,10] Around the age of 5 years, children's basic motor skills should be sufficiently developed to be able to learn advanced motor skills that are needed for sports and academic, social, and emotional functioning. Therefore, children with any underlying cause of a motor developmental problem can benefit from an assessment at age 5. This is so, since a stimulating learning environment and a pro-active approach of school may prevent or reverse an on-going delay in motor development.[4]

In the Netherlands, Preventive Child Health Care (PCHC) professionals, pediatric physiotherapists (on indication), and an increasing number of physical education (PE) teachers at primary schools assess the motor skills at age 5, using different performance-based tests.[11] PCHC professionals use the Baecke-Fassaert Motor Test (BFMT)[12–14], pediatric physiotherapist generally use the MABC,[15,16] while a large number of PE teachers in Dutch primary schools use the 8- or 4- Skills Scan[17–20] to assess the gross motor skills at this age.

In contrast to validated questionnaires on motor skills, evidence lacks regarding the discriminative ability of these frequently applied Dutch performance-based tests. Until now,

nor the BFMT or the 8- or 4-Skills Scan have been studied extensively. The BFMT has been normed for Dutch children aged 5 to 6,5 years (n=1800), in primary education in 1984. In 2016, the BFMT has been compared with the Dutch version of the MABC-2 (n= 61) showing a fair value of the Cohen's kappa (0.45; 95% CI: 0.28-0.61).[21] Regarding the 8- or 4-Skills Scans: no scientific literature can be found on the clinimetric characteristics of these tests.
Therefore, our first aim was to investigate the concurrent validity and discriminative ability of the BFMT, the 8-Skills Scan and the less extensive version of this test, the 4-Skills Scan, with the Dutch version of the MABC as the reference for motor skills.
Typically, motor skills are categorized into two groups: gross motor versus fine motor skills, which represent different aspects of motor development. Delays in gross and fine motor skills require different types of treatment.[22,23] Therefore, the second aim was to assess the concordance between the total, gross, and fine motor scores within and between tests, because the 8- and 4-Skills Scan are used to test gross motor skills only.

Methods

Design, Setting and Population

The motor skills of 5-year-old children from three primary schools, situated in different parts of Amsterdam, were assessed during their physical education lessons. Inclusion criteria for analysis were the following: (1) the child had no medical history with problems, such as a physical or neurological disability, that could influence motor development; and (2) the child had an IQ rating ≥70.
First, written consent was obtained from schools to participate in the study before parents of children were asked to participate in the study. Then, parents of all children and the teachers were informed during an information meeting and handed a written information letter, accompanied with the opportunity to opt-out. The Ethics Committee Human Movement Sciences, VU University Amsterdam, assessed that the rules laid down in the Medical Research Involving Human Subjects Act (also known by its Dutch abbreviation WMO), did not apply to this research proposal.

Sample Size Calculation

The power calculation was based on the binormal approximation to the standard errors of the AUC.[24] On the basis of the cut-off at the 15^{th} percentile of the MABC, the total sample size needed was N=99, in order to find an AUC of 0.8 as significantly different from 0.6 (which we assumed that would be the AUC on the basis of medical judgment by professionals), with a power of 80% and a confidence of 95%.

Procedure

All children were tested on the same day. The first child started with the MABC (followed by the BFMT and the 8- and 4-Skills Scan), the second with the BFMT (followed by the 8- and 4-Skills Scan and the MABC), and the third with the 8- and 4-Skills Scan (followed by the MABC and the BFMT), and so on. All motor tests were performed by two assistants, who were trained in applying and scoring the tests according to strict protocols.

Measurements

Baecke-Fassaart Motor Test (BFMT). The BFMT assesses gross and fine motor skills for children aged 5 to 6.5 years, and takes about 10 minutes per child[13,14] (see Table 1). The assessment of each item consists of two categories: sufficient (score=1) and insufficient motor control (score=0). The maximum score is 13 points. Finally, the total (or sum) scores of these items can be compared with age- and gender-specific scores of a norm group, which have been transformed into percentiles. According to Laurent de Angulo et al.,[13] in PCHC practice the cut-off score is set at the 10th percentile (P10), corrected for age and gender. A score below this cut-off is considered as indicating a delay of motor development.[13,14]

8- and 4-Skills Scan. The 8- and 4-Skills Scan both assess gross motor skills for the ages 2 to 13 years. The 4-Skills Scan is the result of an experts' consultation to make the 8-Skills Scan more feasible, resulting in a choice for four items which are most discriminating, but still covering the three domains of the 8-Skills Scan (see Table 1). The 4-Skills Scan has been proven a reliable test,[19] and includes the following items: 'bouncing (ball)', 'one-leg balance', 'jumping force', and 'jumping coordination'.

Each sub-scale of the 8- and 4-Skills Scan is divided into 9 difficulty levels; and each level matches a certain calendar age between 2 and 13 years. Therefore, the 8- and 4-Skills Scans can be seen as a matrix with 8 (or 4) (sub-scales) times 9 possibilities, and motor age as the main outcome measure. For the 4-Skills Scan, raw data were converted into motor age as follows:

$$Motor\ age\ = \frac{(level\ 'balance' + level\ 'jumping\ force' +\ level\ 'jumping\ coordination' +\ level\ 'bouncing\ ball')}{4}$$

For the 8-Skills Scan, raw data were converted likewise, whereby the nominator equals 8 and the denominator equals the sum of the scores of all 8 sub-scales. Testing takes about 8 and 16 minutes per participant, respectively.

MABC. The MABC, validated in the Dutch population, was used as a reference standard, assessing both gross and fine motor skills (see Table 1). The MABC is used worldwide and is considered to be a reliable and valid instrument for assessing motor skills,[15] and has been used as a standard in numerous studies to assess the validity and discriminative ability of motor tests.[25–28] We used the first version of the MABC because, at the time of the measurements (2012-2014), the MABC-2 had not yet been fully implemented in the Netherlands. Furthermore, at that moment, most other motor screening tests have been validated with this version, enabling a better comparison between studies.

In the Netherlands, the MABC is mandatory to establish the diagnosis DCD.[16,29]. The MABC results in a 'Total Impairment Score'. This implies that a higher score signifies a reduced level of motor skill mastery. The MABC takes about 30 minutes per participant.

Table 1. Test items of the MABC, the BFMT and the 8 and 4-Skills Scan

Sub-scales	MABC	BFMT	8- and 4-Skills Scan
Fine motor skills	posting coins in a bank box	copying figures	
	drawing a line into a trail	drawing a line into a trail	
	threading beads	putting dots	
		finger-thumb opposition	
		eye movements	
		top-nose test	
		diadochokinesis	
		tying shoelaces	
Gross motor skills			
Ball skills	catching a bean bag		bouncing ball*
	rolling a ball into a goal		catching a ball
Balance	one-leg balance	one-leg balance	one-leg balance*
	jumping over a cord	walking on a line	balancing (on a beam)
	walking heels raised on a line	heel walking	
Locomotion		hopping	jumping force*
Other		jumping over a line	jumping coordination*
			climbing
			rolling over

* These items belong to both the 8- and 4-Skills Scan; the other items only belong to the 8 Skills Scan

Statistical Analyses

We assessed the concurrent validity between the total, gross, and fine motor scores within and between the tests, on the basis of Spearman's correlation coefficients, as the data were not normally distributed.

The discriminative ability of the BFMT and the 8- and 4-Skills Scan was assessed by calculating the area under the ROC-curve (AUC). The 15th percentile of the MABC was used as the cut-off score. This was done based on the original reference population as can be found in the MABC manual.[16] With that, including both more serious and mild motor problems.[27,29] Both conditions need follow-up and/or treatment.[27] The 15th percentile of the original reference population is not given in the MABC manual for the fine and gross motor sections separately. Therefore, in order to assess the discriminative ability based on the gross or fine motor section of the MABC separately, the 15th percentile on the MABC of our study sample was chosen as the reference cut-off value for the total, gross, and fine motor sections of the BFMT, and the gross motor section of the 8- and 4-Skills Scan. These cut-off values corresponded to a motor score of 9.0 (total), 7.0 (gross) and 3.7 (fine), respectively.

Sensitivity and specificity of the motor scores were calculated at optimal cut-offs using the MABC as the reference standard. Optimal cut-off values were calculated with the Youden Index (Youden index (J) = max (sensitivity + specificity - 1),[30] giving equal weight to sensitivity and specificity. For the BFMT, sensitivity and specificity were also calculated at the current applied cut-off point (namely P10; which is not necessarily equal to the optimal cut-off, as calculated in this study).

The primary purpose of screening tests is early detection of (potential) health disorders or its risk factors in the general population. For this, the usual requirement for screening tests is a sensitivity of at least 80% and a specificity of at least 90%.[31]

Missing Data

A pairwise handling of missing data was used. There were missing values in one of the test-items of the 8- or 4-Skills Scan of 5 children. Therefore, the analyses were based on n=111 (involving the 8- or 4-Skills Scan) or n=116 (not involving the 8- or 4-Skills Scan). Analyses were performed with SPSS statistical software, version 26.0 for Mac (SPSS Inc. Chicago ILL).

Results

Background Characteristics

A total of 116 children, 48 boys (40%) and 71 girls (60%), participated in the study. Their mean age was 5.6 years (SD: 0.28). For 5 children, the tests results of the 8- and 4-Skills Scan were missing, because of missing test item values. In total, 14 children fell below the 15th percentile, according to the MABC. The gender and age distribution of the schools, which were situated in neighborhoods with a different socio-economic status, is shown in Table 2.

Table 2. Background characteristics of the children (N=116) over the three schools, supplemented with the data from the MABC, BFMT, 8- and 4-Skills Scan

		School		
Ethnicity[26] *	Total	A	B	C
Western (%)	51.6	89.9	36	50.2
Non-Western (%)	48.4	10.1	64	49.8
SES z-scores[24,33] **		0.30	1.15	-1.87
Number of children	116	30	22	64
boys (%)	47 (40.3%)	16 (53.3%)	9 (40.9%)	23 (35.9%)
girls (%)	69 (59.7%)	14 (46.7%)	13 (59.1%)	41 (64.1%)
Mean age in years (SD)	5.55 (0.28)	5.51 (0.31)	5.36 (0.31)	5.52 (0.29)
Mean and standard deviation for test results of the MABC, BFMT, 8- and 4-Skills Scan				
M-ABC total	4.04 (4.22)	3.40 (3.45)	5.36 (4.97)	3.88 (4.24)
M-ABC gross	2.82 (3.16)	2.42 (2.72)	3.30 (3.16)	2.85 (3.37)
M-ABC fine	1.18 (1.75)	0.83 (1.50)	2.07 (2.18)	1.03 (1.61)
BFMT total	8.97 (2.18)	9.33 (1.86)	8.55 (2.30)	8.94 (2.27)
BFMT gross	4.23 (0.94)	4.30 (0.88)	4.18 (1.01)	4.22 (0.95)
BFMT fine	4.73 (1.67)	5.03 (1.56)	4.36 (1.87)	4.21 (0.95)
8-Skills Scan	5.18 (0.42)	5.17 (0.28)	5.04 (0.46)	5.23 (0.45)
4-Skills Scan	5.33 (0.54)	5.28 (0.42)	5.14 (0.56)	5.43 (0.58)

MABC: Movement Assessment Battery for Children; BFMT: Baecke Fassaart Motor Test

* Ethic origin as defined by the Municipality of Amsterdam[26] is based on someone's migration background by: one's country of birth (first generation) or by mother's country of birth (second generation).

** The socioeconomic status scores (SES), which are made available by the Social and Cultural Planning Office (SCP) in The Hague, the Netherlands, are composed of three elements: income, employment and education level. This status scores can be considered as a global estimation of the socioeconomic status of the parents of the children at these schools.[32]

Concurrent Validity

Table 3 lists the correlations between the gross and fine motor section, and the total score of the MABC, BFMT, and the 8- and 4-Skills Scan for all children. All correlations were significant ($p<0.01$). The correlations between the total motor scores of the BFMT and the MABC were moderate[33,34]: r = -.58 (95% CI: -.69 to -.43).

Gross motor skills section. The correlations regarding the gross motor scores between the BFMT, 8- and 4-Skills Scan and the MABC were moderate to strong: r= -0.65 (95% CI: -.76 to -.52), -0.63 (95% CI: -.73 to -.49), and -0.51 (95% CI: -.64 to -.35) respectively.

Fine motor skills section. The correlation between the fine motor score of the BFMT and the fine motor score of the MABC was moderate (see Table 3).

Gross and fine motor skills section. The correlations between gross motor sub-scores and fine motor sub-scores, within or between tests, were moderate but significant and varied between 0.30 and 0.45.

The correlation between the total score and the sub-scores within tests differed remarkably. The relationship between the total and fine motor skills of the BFMT was stronger than between the total and gross motor score of the BFMT; whereas a stronger relation was found between the total and gross motor score of the MABC than between the total and fine motor score of the MABC. This suggests that the contribution of the separate gross and fine motor score to the total motor score differed substantially for the MABC and BFMT.

Table 3. Spearman's correlation coefficients (with 95% CI) between the MABC, the BFMT and the 8- and 4-Skills Scan (N = 111)

	MABC gross	MABC fine	BFMT total	BFMT gross	BFMT fine	8-Skills Scan	4-Skills Scan
MABC total	.93 (.90 to .95)	.68 (.55 to .77)	-.58 (-.69 to -.43)	-.63 (-.75 to -.50)	-.40 (-.56 to -.22)	-.65 (-.76 to -.53)	-.56 (-.68 to -.42)
MABC gross		.41 (.24 to .56)	-.53 (-.64 to -.37)	-.65 (-.76 to -.52)	-.34 (-.50 to -.15)	-.63 (-.73 to -.49)	-.51 (-.64 to -.35)
MABC fine			-.48 (-.61 to -.33)	-.39 (-.54 to -.21)	-.40 (-.55 to -.23)	-.45 (-.59 to -.28)	-.43 (-.57 to -.26)
BFMT total				.68 (.56 to .78)	.92 (.88 to .94)	.48 (.31 to .61)	.44 (.27 to .57)
BFMT gross					.36 (.19 to .52)	.58 (.43 to .70)	.49 (.33 to .63)
BFMT fine						.32 (.14 to .48)	.30 (.11 to .45)
8-Skills Scan							.83 (.75 to .89)

All correlations are significant at $p < .01$
MABC: Movement Assessment Battery for Children; BFMT: Baecke-Fassaart Motor Test

Discriminative Ability

Table 4a displays the AUC and the sensitivity and specificity for the BFMT and 8- and 4-Skills Scan related to the cut-off score of the MABC, representing the 15th percentile score in the reference population.[27] These AUC's ranged from 0.844 to 0.905. The sensitivity and specificity of these tests at optimal cut-offs ranged from 78.6 to 92.2% and from 73.2 to 78.4% respectively. It should be noted that the sensitivity and specificity of the BFMT at currently applied cut-offs (P10) was quite different, namely 35.7 and 93.1% respectively, suggesting other cut-offs should be used for the BFMT.

Table 4b displays the results related to the 15th percentile scores calculated on the basis of our own study population for the total, gross, and fine motor scores. For the total motor scores of the BFMT, the 8- and 4-Skills Scan, the results were very similar to the results when using the 15th percentile of the MABC in the reference population. The AUC's for the gross motor scores of the BFMT and the 8- and 4-Skills Scan using the 15th percentile of the study population ranged from 0.746 to 0.884. With respect to the gross motor scores, the sensitivity was highest for the 4-Skills Scan and the specificity was highest for the BFMT. The AUC for the fine motor score of the BFMT was 0.709, with a sensitivity of 68.8 and a specificity of 64.0% at optimal cut-offs. Based on the information in Table 4, the number of children that have been categorized correctly as having a motor problem or not having a motor problem, on the basis of the three motor skill tests, can be found in Table 5. Figure 1 displays ROC-curves for the main analyses, with figure 1a representing the ROC-plot for the total test scores of the BFMT, 8- and 4-Skills Scan with the total MABC as reference. Figure 1b represents the ROC-plot of the gross motor section of the BFMT, 8- and 4-Skills Scan with the gross motor skills section of the MABC as reference. In Figure 1c, the ROC-plot of the fine motor section between the BFMT and the fine motor skills section of the MABC is presented.

Table 4. AUC, sensitivity, specificity for cut-off values of the BFMT, the 8- and 4-Skills Scan (N range from 111 to 116).

Table 4a. The total motor scores using the MABC as reference, with the 15th percentile in the reference population.

(MABC total)	BFMT total*	8-Skills Scan	4-Skills Scan
N	116	111	111
Cut-off score	7.5	5.1	5.1
Sensitivity (%)	78.6	92.2	78.6
Specificity (%)	78.4	73.2	76.3
AUC (95% CI)	0.853 (0.757-0.949)	0.905 (0.837-0.972)	0.844 (0.730-0.957)

* At the currently applied cut-off score, the sensitivity =35.7% and the specificity = 93.1%

Table 4b. The total motor, gross motor, and fine motor scores, using the MABC as reference, with the 15th percentile of the current study population.

(MABC total)	BFMT total	8-Skills Scan	4-Skills Scan
N	116	111	111
Cut-off score	7.5	5.1	5.1
Sensitivity (%)	77,8	94,4	72,2
Specificity (%)	80,6	76,3	77,4
AUC (95% CI)	0.869 (0.786-0.952)	0.903 (0.843-0.963)	0.828 (0.726-0.929)

(MABC gross)	BFMT gross	8-Skills Scan	4-Skills Scan
N	116	111	111
Cut-off score	4.5	5.1	4.9
Sensitivity (%)	100	88,2	47,1
Specificity (%)	61,2	74,5	92,6
AUC (95% CI)	0.884 (0.818-0.949)	0.870 (0.790-0.951)	0.746 (0.613-0.878)

(MABC fine)	BFMT fine
N	116
Cut-off score	4.5
Sensitivity (%)	68.8
Specificity (%)	64.0
AUC (95% CI)	0.709 (0.585-0.834)

Table 5. Children with an indication for a motor problem according to the MABC in relationship to a 'motor problem' and 'no motor problem' according to the BFMT, 8- and 4-Skills Scan

Test		MABC total	
		≤ PC 15th	> PC 15th
BFMT (optimal cut-off)	motor problem	11	22
(n=116)	no motor problem	3	80
BFMT (at P10)	motor problem	5	7
(n=116)	no motor problem	9	95
8-Skills Scan (optimal cut-off)	motor problem	13	26
(n=111)	no motor problem	1	71
4-Skills Scan (optimal cut-off)	motor problem	11	23
(n=111)	no motor problem	3	74

MABC: Movement Assessment Battery for Children; BFMT: Baecke Fassaart Motor Test

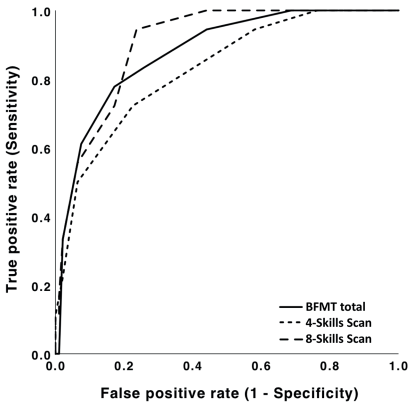

Fig 1a. ROC plot with total MABC as state variable

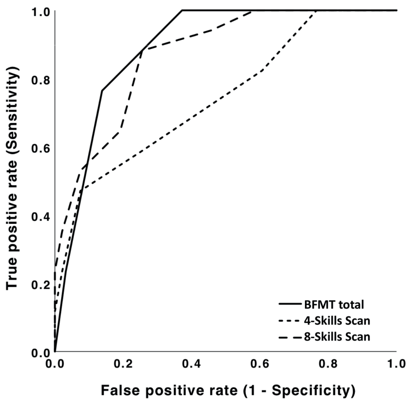

Fig 1b. ROC plot with MABC gross as state variable

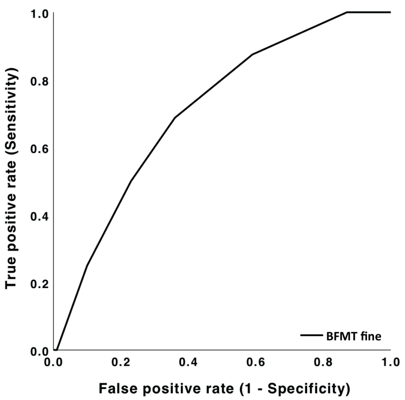

Fig 1c. ROC plot with MABC fine as state variable

Figure 1. ROC plots of the BFMT (N=116) and the 8- and 4-Skills Scan (N=111) for the total scores (Figure 1a), the gross motor scores (Figure 1b), and the fine motor scores (Figure 1c); related to the cut-off values of the total, gross and fine motor scores respectively (i.e. the 15th percentile) of the MABC, assessed in this population of 5-year-old children

Discussion

Our aim was to investigate the concurrent validity and discriminative ability of the BFMT, the 8- and 4-Skills Scan with the MABC as reference standard. This was done for the total, gross and fine motor scores separately. Optimal cut-offs for the BFMT, the 8- and 4-Skills Scan were assessed. For the BFMT, the sensitivity and specificity were calculated for both the currently used and for the optimal cut-off values.

Concurrent Validity and Discriminative Ability

We found strong correlations between the total motor scores and gross motor scores of the BFMT, the 8- and 4-Skills Scan, and the MABC. Our results with respect to the 4 Skills Scan are in line with other study results of our group in which we found the same correlation of the 4-Skills Scan with the total motor score of MABC-2 for 5-9 years olds as in this study with the MABC for 5-year olds (i.e. r=0.56).[20]

The correlations between the gross and fine motor scores within the four tests and between the four tests were low to moderate, indicating that gross and fine motor skills should be considered as separate aspects of motor skills. In other words, a sufficient total motor score may mask a deficient fine or gross motor score. At optimal cut-offs – as determined by the Youden Index – the discriminative ability of the total motor scores of the BFMT and the gross motor scores of 8- and 4-Skills Scan were reasonably high. The discriminative ability of the gross motor scores of these three tests was moderate to high, whereas the discriminative ability of the fine motor score of the BFMT was moderate. It should be noted that the sensitivity of the BFMT, with the use of currently applied cut-offs, was low. This may be caused by the fact that the currently applied cut-off value, which is the 10th percentile (P10), does not match the cut-off value of the MABC, which – in the case of the MABC – is the 15th percentile.[15,16]

None of the scores of the BFMT, the 8- and 4-Skills Scan fully met the criteria for diagnostic accuracy for screening of motor skills, which – according to the American Psychological Association – should have a sensitivity ≥80% and a specificity ≥90%.[31] However, the correlations and diagnostic accuracy of the total and gross motor scores were close to acceptable. These unfavourable findings of concurrent validity and diagnostic accuracy are in line with other studies on performance-based motor skills tests, with exception of

one study about the MOT 4-6, which had a high sensitivity (88%) and specificity (90%) in a population of Belgian children.[35] Though, the MOT 4-6 takes more time (15 to 20 minutes) in comparison to the BFMT, the 8- and 4-Skills Scan (with 10, 16, and 8 minutes, respectively), and is therefore less suitable for screening purposes in a practical setting.
Remarkably, at optimal cut-offs for the gross motor section of the BFMT, the sensitivity was 100%, whereas the specificity was only 61.2%. For the next most favourable cut-off, according to the Youden index, the sensitivity was 72.2% and the specificity 86.7%. This phenomenon may be explained by the fact that the scales of the sub-items of the BFMT are dichotomous. The test-items on the subscales of the 8- and 4-Skills Scan have more categories, allowing for a more precise assessment of motor skills development.

In studying the correlation between the gross and fine motor section and the total test scores, we found a stronger correlation between the gross motor section of the MABC with the total MABC, than between the fine motor section of the MABC and with the total MABC. This is in line with the study of Van Waelvelde et al.[25,26] In contrast, we found a stronger correlation between the total motor score of the BFMT and the fine motor section of the BFMT, than between the total motor score of the BFMT and the gross motor section of the BFMT. These findings suggest that fine motor section contributed more to the final score of the BFMT, and the gross motor section more to the total motor score of the MABC. Differences in the proportion of gross motor and fine motor test items relative to the total test items might engender these outcomes. For both the MABC and the BFMT, the total test score is the sum of all the individual test items. Therefore, the number of test items per fine or gross motor category matter. For the MABC, out of the 8 test items, there were 5 gross motor test items (63%) and 3 fine motor test items (37%); while for the BFMT, out of the 13 test items, there were 5 gross motor skill test items (38%) and 8 fine motor skill test items (62%).

The low correlations between gross and fine motor scores, in combination with the large difference between proportions of gross and fine motor test items of the M-ABC and the BFMT, may partly explain why the BFMT does not meet the requirements for screening yet. In addition, differences in motor construct between these tests might affect their mutual correlation.[36] This may influence the validity of the tests negatively.

Strengths and Limitations

An important strength of the study regards the use of designated test assistants who had not had previous contacts with these children, and the application of all tests on the same day whereby the first test for the children alternated, therefore preventing sequence effects. Another strength is that we studied the motor tests in a general population of healthy children from primary schools. A limitation may be that the MABC may not be a perfect reference test. This is because it has been argued that some skills, such as handwriting and functional performance, are not being measured by the MABC or MABC-2.[37] However, the MABC-2 is currently considered to be the best choice as reference test.

It has been shown that the standard scores of the MABC-2 better meet, although not completely, the assumptions of a normal distribution.[38,39] Therefore, we applied non-parametric tests to assess correlations of the tests with the MABC. Although we used the previous version of the MABC-2, namely the MABC-1, we do not expect this to have a major impact on the conclusions of this study. The age-band for 5-year-old children of the MABC-2 is highly comparable to the first version of the MABC. The basic skills that are being tested are the same for MABC-1 and MABC-2, and only two test-items have been replaced by comparable test-items (i.e. the test item "rolling ball into goal" has been replaced by "throwing beanbag onto mat" which both assess throwing skills, and the test item "jumping over cord" by "jumping on mats", which both assess balance).[38] In addition, the correlations of a well-known motor test, the KTK, with the MABC-1 and the MABC-2 are equal,[40,41] implying that the differences between the MABC-1 and the MABC-2 is probably small.

Also, the norm population of the MABC-1 (and MABC-2) is likely to be different with respect to ethnicity, although this has not been described for the MABC-1 or MABC-2.[16,37,40] This might have influenced the prevalence of motor problems in our population, since it is known that motor difference can be found between children with different cultural and/or ethnic backgrounds at a young age.[42] However, it is not very likely that the correlation between tests is influenced by ethnicity of the children. Besides, at least half of the variance in motor skills is likely to be influenced by the environment.[43]

Implications

Before definitive conclusions can be drawn about the value of the BFMT, 8- and 4-Skills Scan as screening instruments, this study should be replicated in other populations with the MABC-2. Subsequently, adaptations of the tests that better align the construct of motor skills with the MABC are recommended in order to improve the sensitivity and specificity. At this time, with respect to the BFMT, a relative quick and easy to implement improvement would be to change the currently applied cut-offs of the BFMT to the optimal cut-offs. Notably, replacing the dichotomous scales of the sub-items of the BFMT by using a scale with more categories or a continuous scale will probably also result in a better balance between sensitivity and specificity. Assessing cut-offs for gross and fine motor skills separately should be considered, as the correlation between gross and fine motor scores are low to moderate and therapeutic consequences of gross and fine motor skills problems differ. Finally, the decision on cut-offs should also be determined by whether a higher value is attached to a high sensitivity or, on the contrary, to a high specificity.

We recommend screening for motor skills at age 5, because of the possible serious academic and social impact of a motor skills delay later in life.[6–8] Gross motor skills screening at this age allows for early detection of delayed motor skills and the use of effective interventions.[4,44] The examined motor skill tests did not fully meet the criteria for diagnostic accuracy for screening of motor skills. Yet, in a step-wise approach for motor skill screening, the BFMT, 8- or 4-Skills Scan could be used for screening purposes. This is particularly the case if screening can be done in the school setting, since all children attend school. This can be achieved by applying a sequential application of motor tests, such as gross motor skills screening at school, that if necessary, is followed by a more extensive motor skills test performed by the Preventive Child Health Care (PCHC) professional or pediatric physiotherapists. Such a stepwise approach in screening for motor developmental problems may have added value for the cost-effectiveness in medical decision-making. However, caution should be taken when interpreting the test results of the motor skills tests that were assessed in this study. Hereto, extra anamnestic information could support medical decision-making.

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Conflicts of Interest

We declare that there are no conflicts of interest.

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